6. ADDITIONAL SUPPORTING ANALYSES

6.1 INTRODUCTION

As discussed throughout this document, there are numerous challenges posed in trying to predict the distribution of PCBs in various media over a period spanning decades. The physical complexity of the Housatonic River only increases the difficulties of making such predictions. Although the emphasis has been placed on the use of deterministic models to address the study objectives, it is prudent to employ alternative analyses that can be used to supplement the modeling analysis and which can be used to reinforce the interpretation of results. This section discusses the additional supporting analyses that will be employed as a “weight-of-evidence” approach to evaluate the extent to which the conclusions derived from the proposed modeling are supported by alternative assessment techniques. These techniques include the use of two alternative modeling tools and a geomorphological investigation. A brief discussion of the purpose and applicability of these tools is provided below.

6.2 APPLICATION OF THE GENERALIZED STREAM TUBE MODEL FOR ALLUVIAL RIVER SIMULATION (GSTARS)

As indicated above in Section 4 of this document, the computational grid scheme developed for this model was originally developed for applications in open water bodies, e.g., estuaries, lakes, and large river systems, where precise mapping of a grid to the shoreline boundary was not a critical factor in the ability to defensibly model the system. Such is not the case in the Housatonic River. The physical complexity of the system in terms of its meanders and relatively narrow width raises the question as to whether the grid scheme would introduce a bias into the numerical solution.

To determine whether such a bias exists, the investigation will use a widely applied riverine sediment transport model (Yang et al., 1998; Molinas and Yang, 1986). This model incorporates many features that make it an appropriate tool to evaluate the concerns raised above. Unlike traditional 1-D models, GSTARS allows the specification of one or more stream tubes,[1] which provides for a quasi 2-D solution for flow and sediment routing. The stream tube approach allows for scour and deposition to be computed across the channel.

Unlike the grid schemes available for use with EFDC, GSTARS allows for the detailed specification of the channel cross-section dimensions. Instead of a vertical rectangular cell that cannot map to the complex boundaries of the channel cross-section, changes in flow with depth can be closely simulated with GSTARS. Longitudinally, the lengths of discrete stream tube sections are simply specified. Laterally, the river is specified using up to seven stream tubes (typically three in the channel and one or two in the "floodplain" on each side) across the width of the channel.

The principal sediment transport formulation within the GSTARS model is based on the unit stream power approach developed by the model's author (Yang, 1976). The unit stream power approach is based on the concept that changes in river channel geometry occur as a result of the system striving to achieve a minimum rate of energy dissipation necessary to maintain a stable channel form. More specifically, the author states "for subcritical flow in an alluvial channel, the channel will adjust its velocity, slope, roughness and geometry in such a manner that a minimum amount of unit stream power is used to transport a given sediment and water discharge." Unit stream power is defined as the product of flow velocity and channel slope (VS).

The theory of minimum rate of energy dissipation (Yang and Song, 1979) holds that the ability of the system to maintain a dynamic equilibrium condition is accomplished by adjusting numerous physical variables (e.g., pattern, geometry, bed form, roughness, slope) until such time as a minimum rate of energy dissipation is achieved. Numerous studies on the application of this theory and the GSTARS model to simulate sediment transport in alluvial rivers have been published in the technical literature (Lee et al., 1998; Lee et al., 1997; Song et al., 1995; Yang et al., 1996). The model formulations are well developed for noncohesive sediment transport investigations and should be useful to this investigation, given the prevalence of noncohesive

[1]A stream tube is defined as a portion of a river channel where hydraulic and sediment routing is computed separate from the remainder of the channel. A channel made up of multiple stream tubes provides a means of computing lateral variation in hydraulic and sediment routing.

sediment in the bed in the region above Woods Pond. The model also incorporates numerous other well-known sediment transport formulations (Yang, 1998).

GSTARS incorporates an additional feature that is distinguishable from traditional models in that it allows the user to simulate changes in channel width over time. The variation in mechanical properties of the materials comprising an embankment makes it difficult to predict such changes with accuracy, particularly for embankments made up of both noncohesive and cohesive materials. While this is not a primary reason for using this model, validating this feature of the model against observed field data may provide useful information relevant to this study.

6.3 HEC-6 SCOUR AND DEPOSITION IN RIVERS AND RESERVOIRS

The HEC-6 model (USACE, 1991) is a 1-D model specifically designed to simulate long-term scour and deposition in rivers and reservoirs. Unlike GSTARS and EFDC, HEC-6 is limited to examining changes in bed elevation that occur over extended periods of time. The model was not intended to simulate specific storm events. In addition, the model is principally meant to be applied under conditions of subcritical flows.

For reasons similar to those discussed above for GSTARS, HEC-6 does allow for a detailed specification of the channel geometry. In addition, the user specifies both the lengths of the right and left banks for a specific section. This allows the model to account, to some degree, for the curvature of the channel when performing hydraulic and sediment routing. Since HEC-6 has been widely applied for long-term sediment scour and deposition studies, comparison of long-term results between HEC-6 and EFDC will be used to ensure that predictions between the models are reasonably consistent where applicable (e.g., sediment scour and depositional areas coincide).

6.4 GEOMORPHOLOGICAL INVESTIGATION

There are a number of references in this document to the inability of models to predict the occurrence of numerous geomorphological processes. It has also been stated that these processes are relevant to examining issues of sediment transport. In lieu of suitable modeling techniques, some quantitative measure of the significance of these processes is clearly warranted.

It is widely accepted that changes in the pattern, profile, and dimension of a river channel go hand-in-hand with changes in fluvial processes. This goes to the concept of "natural river stability" in that a river evolves to a form that will result in a stable channel configuration. Changes occurring within the tributary watershed to the river may or may not result in changes in the physical characteristics of the channel. A stable channel can be described as one where its features remain unchanged and the channel is neither aggrading or degrading (Rosgen, 1994a).

A number of historical changes have occurred within the Housatonic River basin that have resulted in physical changes to the river. Numerous references to these physical changes in the river have been cited in this document. The principal concern is whether these changes constitute a departure from what would be normally be encountered in similar systems, or whether they are representative of the influences of anthropogenic effects. A mechanism to assess the degree of departure, if any, has been developed by Rosgen (1985, 1994a) and has been widely applied. This method incorporates quantitative metrics that describe the pattern, profile, and dimension of the river channel. Using these metrics, departures from a stable channel configuration can be derived from comparisons with unimpacted systems residing within the same physiographic region. A principal concern for this investigation is to determine whether physical processes are occurring that are contributing to channel instability and whether those processes are accelerated as a consequence of man-made influences. If circumstances were to demonstrate that man-made influences are contributing to channel instability and thus increasing the rate at which channel evolution is occurring, then this goes to the issue of the overall stability of the river system and to the possibility that PCBs adsorbed to bank and floodplain sediments will be reintroduced into the system.

Under this investigation, a geomorphologic characterization of the study area will be performed. As part of this investigation, successive regions of the system will be classified according to the techniques devised by Rosgen (1994b). The classification of each region of the river will be compared to a river system within the same physiographic region that is reaching its potential, i.e., is unimpacted. The extent of the departure from its potential will be used as a basis for determining whether man-made influences are contributing to channel instability within the system. In addition, control sections will be established in the meander region where toe pins will be installed in channel banks to measure the rate of change in channel width over time. In addition, detailed cross-sectional measurements will be made periodically to determine changes in bed elevation and bed substrate.